ABSTRACT: A database of 1188 observations with 11 monthly weightings from weaning to 18 month of age of 108 Buffalypso graded males buffaloes from “Los Naranjos” enterprise at Artemisa province was utilized. A non-lineal mixed model (PROC NLMIXED from SAS, 2007) was applied where fixed effects were: weaning month and year. Individual weights were adjusted to the corresponding ages Different non lineal models variants are studied: Logistic, Gompertz, Brody and Von Bertalanffy including to β₀ parameter the random component b₀. The β₀, β₁ and β₂ parameters were considered as fixed effects. The goodness of fit criteria were: maximum likelihood criterion, Akaike information criterion and bayesian information criterion. The Logistic and Gompertz models attained the best adjustments to describe growing curves of the population under study.

Keywords: buffaloes growing curve mixed models

Introduction

Since the 80’s decade, bubalines are reared in Cuba and at this moment, there are around 57 559 heads distributed throughout the country employed as alternative for milk, beef and draft (Anon, 2013). Several studies had reported buffaloes as a precocity beef producer animal on grassing systems (Amorin et al. 1999) and also, that comparing them with cattle, they have better growing rates to reach slaughter weights (Agudelo et al. 2007).

One way to describe the growing characteristics of beef cattle is to study growing curves by using statistical models able to estimate several parameters, which permits to conduct evaluations at different growing periods.

The most frequent functions used to model animal growing period are the linear, polinomic and the non-linear ones which were proposed by Gompertz in 1825, Verhulst in 1838 known as logistic, (Brody (1945), Von Bertalanffy (1957), Richards (1959)). All of them intend to predict adult weights and mature grades at a particular animal life moment without conducting repeated measurements or waiting for the animals to reach maturity to take decisions related with management and production.

Recently, mixed models has been utilized which make possible to analyze fixed and random effects relating them with the response variable considered. The first reports considering theory and application of mixed models were conducted by Pinheiro and Bates in 1995. The application of mixed models gives the possibility to analyze data with dependency structures, non-balanced and in some occasions without normality and to model in a flexible manner complex structured databases (El Halimi (2005)).

In Cuba, there are not enough studies related with non-linear mixed models to characterize buffalo growing curves and therefore, the objective of this paper was to estimate the most appropriate male bubaline growing curve models employing non lineal mixed models.

Materials and Methods

Database: A database of 1188 observations corresponding to 11 monthly weightings, since weaning, at 8 month, to 18 month of age of 108 graded Buffalypso males buffaloes was utilized. Data were issued from 16 herds belonging to the performance test station of “Majana” from the “Los Naranjos” Cattle Enterprise located at the Artemisa province, Cuba. Animals were born between 2007 and 2012 and reared on natural grassland which received additional forage, water and natural shade.

Models used to describe the animal growth curve were: Gompertz (1825), Logistic (1938), Brody (1945) and Von Bertalanffy (1938).

The different models were analyzed using the Gauss-Newton algorithm with the Proc NLIN option of the SAS (2007) packet version 9.1.3, permitting to run a previous parameter estimation of β₀, β and β₂. Afterwards a last parameter estimation was run through a non-linear mixed model considering only a parameter (b₀) as random effect with N (0, σ²b₀). The β₀, β₁and β₂ parameters were considered as fixed effects and estimated using the Proc NLMIXED of SAS (2007) packet version 9.1.3.

To select the best adjusted model the goodness of fit criteria: Maximum Likelihood Function (Likelihood -2 Log), Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) were taken into account.

Results and Discussion

The estimated parameter values of curves are showed in table 1. The β₀ parameter is defined as the asymptotic weight or adult weight, and it represents the estimation of mature weight, independently of fluctuations of weight associated to genetic and environmental variation effects (Silva et al. 2001).

The comparison of these obtained weights (β₀) from the 4 models expressed that the greater value was obtained with the Brody model (238.9 ± 4.0 kg) and the
lower with the Logistic (232.9 ± 2.8 kg). These results are corroborated by findings of Torres et al. (2012) with 15 bubaline females of similar genetic group used in this study also on pasture. Although, in this other study, an overestimation of this parameter in the Brody model (1053.33 ± 68.74 kg) was encountered. In Brasil, Malhado et al. (2008) utilized data of 236 buffaloes (males and females) of the Murrah breed, from birth to 40 months of age reared on pasture of northeast region supplemented during the dry season and belonging to the Bubaline Breeding Program (Promebul). It was possible to verify that the greater value was obtained with the Brody model (688.0 ± 4.6 kg) and the lower one with the logistic curve (601.9 ± 2.3 kg).

Table 1. Estimated parameters ($\beta_0$, $\beta_1$ and $\beta_2$) from the mixed models evaluated.

<table>
<thead>
<tr>
<th>Models</th>
<th>$\beta_0$</th>
<th>$\beta_1$</th>
<th>$\beta_2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brody</td>
<td>238.9±3.9</td>
<td>1.20±0.14</td>
<td>0.005±0.001</td>
</tr>
<tr>
<td>Von</td>
<td>236.6±3.3</td>
<td>0.54±0.07</td>
<td>0.006±0.001</td>
</tr>
<tr>
<td>Bertanlaffy</td>
<td>235.5±3.3</td>
<td>1.86±0.23</td>
<td>0.007±0.001</td>
</tr>
<tr>
<td>Gompertz</td>
<td>233.0±2.8</td>
<td>2.92±0.40</td>
<td>0.008±0.001</td>
</tr>
<tr>
<td>Logistic</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

In the case of $\beta_1$ parameter, known as the integration parameter, it lacks of biological signification and is only used to adequate the initial live weight of animals (Mendes et al. 2001).

According to Silva et al. (2004) another important parameter is $\beta_2$, known as the mature indexes which determine the growing efficiency of an animal. The increase of this parameter means precocity; therefore a lower value indicates a later maturity and represents an expression of velocity as the animal is reaching its adult weight. With the estimation of this parameter occurs the opposite found for the A parameter, and the high value corresponded to the logistic model (0.0078 ± 0.0006) and the lower to Brody model 0054 ± 0.0006. The results here obtained are in correspondence with those notified by Torres et al. (2012) in Cuba and by Araújo et al. (2012) in Brazil.

Based on adjustment bounty criterion evaluated in the present paper (table 2), it was possible to determine that the Logistic and Gompertz models were very similar and had the lower values describing growth, following with those of Von Bertanlaffy and finally with the Brody model’s.

Quintero et al. (2013) selecting the best adjusted model for growing curves in the BON breed found that Brody model brought the best adjustment, showing the lower values of SQE (1666168), AIC (10238) and BIC (1250). This means a good fitting model to simulate and determine growing parameters. Nevertheless, the logistic model showed difficulties to model the growing curve.

Table 2. Fitting Criterion for the analyzed models.

<table>
<thead>
<tr>
<th>Models</th>
<th>Likelihood -2 Log</th>
<th>AIC</th>
<th>BIC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Brody</td>
<td>10353</td>
<td>10362</td>
<td>10387</td>
</tr>
<tr>
<td>Von</td>
<td>10351</td>
<td>10361</td>
<td>10386</td>
</tr>
<tr>
<td>Bertanlaffy</td>
<td>10350</td>
<td>10360</td>
<td>10386</td>
</tr>
<tr>
<td>Gompertz</td>
<td>10350</td>
<td>10360</td>
<td>10386</td>
</tr>
<tr>
<td>Logistic</td>
<td>10350</td>
<td>10360</td>
<td>10385</td>
</tr>
</tbody>
</table>

Several authors (Malhado et al. (2008), Arias et al. (2010), Torres et al. (2012), Araújo et al. (2012) in researches conducted with the bubaline species using other statistic criterion to choose the best adjusted model, obtained similar results to those here presented employing different breeds, different management and feeding systems. Whereas, in a study conducted at Colombia by Ramirez et al. (2011) with 123 castrated males, and evaluating different mixed models of first and second order found that the quadratic model described best the growing phase of bubaline cattle and also, that goodness of fit ameliorates when including random parameters.

Conclusions

Logistic and Gompertz models were the best to describe the growing curve of bubaline graded Buffalypso males according to the statistic criteria evaluated and it is recommended to conduct studies with greater number of animals including other random effects with the objective to select the best animals with higher growing rates.

Literature quoted
